Efficiency of Energy Use in the United States

Transportation, space heating, and air conditioning provide opportunities for large energy savings.

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Conflicts between the demand for energy and environmental quality goals can be resolved in several ways. The two most important are (i) development and use of pollution control technologies and of improved energy-conversion technologies and (ii) the improvement in efficiency of energy use. Increased efficiency of energy use would help to slow energy growth rates, thereby relieving pressure on scarce energy resources and reducing environmental problems associated with energy production, conversion, and use.

Between 1950 and 1970, U.S. consumption of energy resources (coal, oil, natural gas, falling water, and uranium) doubled (*1*), with an average annual growth rate of 3.5 percent—more than twice the population growth rate.

Energy resources are used for many purposes in the United States (*2*) (Table 1). In 1970, transportation of people and freight consumed 25 percent of total energy, primarily as petroleum. Space heating of homes and commercial establishments was the second largest end-use, consuming an additional 18 percent. Industrial uses of energy [process steam, direct heat, electric drive, fuels used as raw materials (*3*), and electrolytic processes] accounted for 42 percent. The remaining 15 percent was used by the commercial and residential sectors for water heating, air conditioning, refrigeration, cooking, lighting, operation of small appliances, and other miscellaneous purposes.

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During the 1960's, the percentage of energy consumed for electric drive, raw materials, air conditioning, refrigeration, and electrolytic processes increased relative to the total. Air conditioning showed the largest relative growth, increasing its share of total energy use by 81 percent, while the other uses noted increased their shares of the total by less than 10 percent in this period.

The growth in energy consumption by air conditioners, refrigerators, electric drive, and electrolytic processes—coupled with the substitution of electricity for direct fossil fuel combustion for some space and water heating, cooking, and industrial heat—accounts for the rapid growth in electricity consumption. Between 1960 and 1970, while consumption of primary energy (*1*) grew by 51 percent, the use of electricity (*4*) grew by 104 percent. The increasing use of electricity relative to the primary fuels is an important factor accounting for energy growth rates because of the inherently low efficiency of electricity generation, transmission, and distribution which averaged 30 percent during this decade (*1, 4*). In 1970, electrical generation (*1*) accounted for 24 percent of energy resource consumption as compared to 19 percent in 1960.

Industry, the largest energy user, includes manufacturing; mining; and agriculture, forestry, and fisheries. Six manufacturers—of primary metals; of chemicals; of petroleum and coal; of stone, clay, and glass; of paper; and of food—account for half of industrial energy consumption (*5*), equivalent to 20 percent of the total energy budget.

Energy consumption is determined by at least three factors: population, affluence, and efficiency of use. In this article we describe three areas in which energy-efficiency improvements (the third factor) might be particularly important: (i) transportation of people and freight, (ii) space heating, and (iii) space cooling (air conditioning).

Energy efficiency varies considerably among the different passenger and freight transport modes. Shifts from energy-intensive modes (airplanes, trucks, automobiles) to energy-efficient modes (boats, pipelines, trains, buses) could significantly reduce energy consumption. Increasing the amount of building insulation could reduce both space-heating and air-conditioning energy consumption in homes and save money for the homeowner. Energy consumption for air conditioning could be greatly reduced through the use of units that are more energy efficient.

Transportation

Transportation of people and goods consumed 16,500 trillion British thermal units (*6*) in 1970 (25 percent of total energy consumption) (*1*). Energy requirements for transportation increased by 89 percent between 1950 and 1970, an average annual growth rate of 3.2 percent.

Increases in transportation energy consumption (*7*) are due to (i) growth in traffic levels, (ii) shifts toward the use of less energy-efficient transport modes, and (iii) declines in energy efficiency for individual modes. Energy intensiveness, the inverse of energy efficiency, is expressed here as British thermal units per ton-mile for freight and as British thermal units per passenger-mile for passenger traffic.

Table 2 shows approximate values (*8*) for energy consumption and average revenue in 1970 for intercity freight modes; the large range in energy efficiency among modes is noteworthy. Pipelines and waterways (barges and boats) are very efficient; however, they are limited in the kinds of materials they can transport and in the flexibility of their pickup and delivery points. Railroads are slightly less efficient than pipelines. Trucks, which are faster and more flexible than the preceding three modes, are, with respect to energy, only one-fourth as efficient as railroads. Airplanes, the fastest mode, are only 1/60 as efficient as trains.

The variation in freight prices shown in Table 2 closely parallels the variation in energy intensiveness. The increased prices of the less efficient modes reflect their greater speed, flexibility, and reliability.

Table 3 gives approximate 1970 energy and price data for various passenger modes (8). For intercity passenger traffic, trains and buses are the most efficient modes. Cars are less than one-half as efficient as buses, and airplanes are only one-fifth as efficient as buses.

For urban passenger traffic, mass transit systems (of which about 60 percent are bus systems) are more than twice as energy efficient as automobiles. Walking and bicycling are an order of magnitude more efficient than autos, on the basis of energy consumption to produce food. Urban values of efficiency for cars and buses are much lower than intercity values because of poorer vehicle performance (fewer miles per gallon) and poorer utilization (fewer passengers per vehicle).

Passenger transport prices are also shown in Table 3. The correlation between energy intensiveness and price, while positive, is not as strong as for freight transport. Again, the differences in price reflect the increased values of the more energy-intensive modes.

The transportation scenario for 1970 shown in Table 4 gives energy savings that may be possible through increased use of more efficient modes. The first calculation uses the actual 1970 transportation patterns. The scenario—entirely speculative—indicates the potential energy savings that could have occurred through shifts to more efficient transport modes. In this hypothetical scenario, half the freight traffic carried by truck and by aiplane is assumed to have been carried by rail; half the intercity passenger traffic carried by airplane and one-third the traffic carried by car are assumed to have been carried by bus and train; and half the urban automobile traffic is assumed to have been carried by bus. The load factors (percentage of transport capacity utilized) and prices are assumed to be the same for both calculations. The scenario ignores several factors that might inhibit shifts to energy-efficient transport modes, such as existing land-use patterns, capital costs, changes in energy efficiency within a given mode, substitutability among modes, new technologies, transportation ownership patterns, and other institutional arrangements.

The hypothetical scenario requires only 78 percent as much energy to move the same traffic as does the actual calculation. This savings of 2800 trillion Btu is equal to 4 percent of the total 1970 energy budget. The scenario also results in a total transportation cost that is $19 billion less than the actual 1970 cost (a 12 percent reduction). The dollar savings (which includes the energy saved) must be balanced against any losses in speed, comfort, and flexibility resulting from a shift to energy-efficient modes.

To some extent, the current mix of transport modes is optimal, chosen in response to a variety of factors. However, noninternalized social costs, such as noise and air pollution and various government activities (regulation, subsidization, research), may tend to distort the mix, and, therefore, present modal patterns may not be socially optimal.

Present trends in modal mix are determined by personal preference, private economics, convenience, speed, reliability, and government policy. Emerging factors such as fuel scarcities, rising energy prices, dependence on petroleum imports, urban land-use problems, and environmental quality considerations may provide incentives to shift transportation patterns toward greater energy efficiency.

Table 1. End-uses of energy in the United States.

Item	1960* (%)	1970† (%)
Transportation	25.2	24.7
Space heating	18.5	17.7
Process steam	17.8	16.4
Direct heat	12.9	11.0
Electric drive	7.4	8.1
Raw materials	5.2	5.6
Water heating	4.0	4.0
Air conditioning	1.6	2.9
Refrigeration	2.1	2.3
Cooking	1.5	1.2
Electrolytic processes	1.1	1.2
Other‡	2.7	4.9

* Data for 1960 obtained from Stanford Research Institute (SRI) (2). † Estimates for 1970 obtained by extrapolating changes in energy-use patterns from SRI data. ‡ Includes clothes drying, small appliances, lighting, and other miscellaneous energy uses.

Table 2. Energy and price data for intercity freight transport.

Mode	Energy (Btu/ ton-mile)	Price (cents/ ton-mile)
Pipeline	450	0.27
Railroad	670	1.4
Waterway	680	0.30
Truck	2,800	7.5
Airplane	42,000	21.9

Table 3. Energy and price data for passenger transport.

Mode	Energy (Btu/passenger-mile)	Price (cents/passenger-mile)
	*Intercity**	
Bus	1600	3.6
Railroad	2900	4.0
Automobile	3400	4.0
Airplane	8400	6.0
	Urban†	
Mass transit	3800	8.3
Automobile	8100	9.6

* Load factors (percentage of transport capacity utilized) for intercity travel are about: bus, 45 percent; railroad, 35 percent; automobile, 48 percent; and airplane, 50 percent. † Load factors for urban travel are about: mass transit, 20 percent; and automobile, 28 percent.

Space Heating

The largest single energy-consuming function in the home is space heating. In an average all-electric home in a moderate climate, space heating uses over half the energy delivered to the home; in gas- or oil-heated homes, the fraction is probably larger because the importance of thermal insulation has not been stressed where these fuels are used.

The nearest approach to a national standard for thermal insulation in residential construction is "Minimum Property Standards (MPS) for One and Two Living Units," issued by the Federal Housing Administration (FHA). In June 1971, FHA revised the MPS to require more insulation, with the stated objectives of reducing air pollution and fuel consumption.

A recent study (9) estimated the value of different amounts of thermal insulation in terms both of dollar savings to the homeowner and of reduction in energy consumption. Hypothetical model homes (1800 square feet) were placed in three climatic regions, each representing one-third of the U.S. population. The three regions were represented by Atlanta, New York, and Minneapolis.

As an example of the findings of the study, Table 5 presents the results applicable to a New York residence, including the insulation requirements of the unrevised and the revised MPS, the insulation that yields the maximum economic benefit to the homeowner, and the monetary and energy savings that result in each case. The net monetary savings are given after recovery of the cost of the insulation installation, and would be realized each year of the lifetime of the home. A mortgage interest rate of 7 percent was assumed.

The revised MPS provide appreciable savings in energy consumption and in the cost of heating a residence, although more insulation is needed to minimize the long-term cost to the homeowner. A further increase in insulation requirements would increase both dollar and energy savings.

The total energy consumption of the United States (*1*) in 1970 was 67,000 trillion Btu, and about 11 percent was devoted to residential space heating and 7 percent to commercial space heating (*2*). Table 5 shows reductions in energy required for space heating of 49 percent for gas-heated homes and 47 percent for electric-heated homes in the New York area by going from the MPS-required insulation in 1970 to the economically optimum amount of insulation. The nationwide average reductions are 43 percent for gas-heated homes and 41 percent for electric-heated homes. An average savings of 42 percent, applied to the space heating energy requirements for all residential units (single family and apartment, gas and electric), would have amounted to 3100 trillion Btu in 1970 (4.6 percent of total energy consumption). The energy savings are somewhat understated—as insulation is added, the heat from lights, stoves, refrigerators, and other appliances becomes a significant part of the total heat required. The use of additional insulation also reduces the energy consumption for air conditioning as discussed later.

Electrical resistance heating is more wasteful of primary energy than is direct combustion heating. The average efficiency for electric power plants (*1*) in the United States is about 33 percent, and the efficiency (*4*) of transmitting and distributing the power to the customer is about 91 percent. The end-use efficiency of electrical resistance heating is 100 percent; so the overall efficiency is approximately 30 percent. Thus, for every unit of heat delivered in the home, 3.3 units of heat must be extracted from the fuel at the power plant. Conversely, the end-use efficiency of gas- or oil-burning home heating systems is about 60 percent (claimed values range from 40 to 80 percent), meaning that 1.7 units of heat must be extracted from the fuel for each unit delivered to the living area of the home. Therefore, the electrically heated home requires about twice as much fuel per unit of heat as the gas- or oil-heated home, assuming equivalent insulation.

The debate about whether gas, oil, or electric-resistance space heating is better from a conservation point of view may soon be moot because of the shortage of natural gas and petroleum. The use of electricity generated by nuclear plants for this purpose can be argued to be a more prudent use of resources than is the combustion of natural gas or oil for its energy content. Heating by coal-generated electricity may also be preferable to heating by gas or oil in that a plentiful resource is used and dwindling resources are conserved.

The use of electrical heat pumps could equalize the positions of electric-, oil-, and gas-heating systems from a fuel conservation standpoint. The heat pump delivers about 2 units of heat energy for each unit of electric energy that it consumes. Therefore, only 1.7 units of fuel energy would be required at the power plant for each unit of delivered heat, essentially the same as that required for fueling a home furnace.

Heat pumps are not initially expensive when installed in conjunction with central air conditioning; the basic equipment and air handling systems are the same for both heating and cooling. A major impediment to their widespread use has been high maintenance cost associated with equipment failure. Several manufacturers of heat pumps have carried out extensive programs to improve component reliability that, if successful, should improve acceptance by homeowners.

Table 4. Actual and hypothetical energy consumption patterns for transportation in 1970.

	Total traffic	Percentage of total traffic						Total energy (10^{12} Btu)	Total cost (10^9 \$)
		Air	Truck	Rail	Waterway and pipeline	Auto	Bus*		
				Intercity freight traffic					
Actual	2210†	0.2	19	35	46			2400	45
Hypothetical	2210	0.1	9	44	46			1900	33
				Intercity passenger traffic					
Actual	1120‡	10		1		87	2	4300	47
Hypothetical	1120	5		12		58	25	3500	45
				Urban passenger traffic					
Actual	710‡					97	3	5700	68
Hypothetical	710					49	51	4200	63
				Totals					
Actual								12,400	160
Hypothetical								9600	141

* Intercity bus or urban mass transit. † Billion ton-miles. ‡ Billion passenger-miles.

Table 5. Comparison of insulation requirements and monetary and energy savings for a New York residence.

Insulation specification	Unrevised MPS*		Revised MPS*		Economic optimum	
	Gas	Electric	Gas	Electric	Gas	Electric
Wall insulation thickness (inches)	0	1⅞	1⅞	1⅞	3½	3½
Ceiling insulation thickness (inches)	1⅞	1⅞	3½	3½	3½	6
Floor insulation	No	No	Yes	Yes	Yes	Yes
Storm windows	No	No	No	No	Yes	Yes
Monetary savings (\$/yr)	0	0	28	75	32	155
Reduction of energy consumption (%)	0	0	29	19	49	47

* Minimum property standards (MPS) for one and two living units.

Space Cooling

In all-electric homes, air conditioning ranks third as a major energy-consuming function, behind space heating and water heating. Air conditioning is particularly important because it contributes to or is the cause of the annual peak load that occurs in the summertime for many utility systems.

In addition to reducing the energy required for space heating, the ample use of thermal insulation reduces the energy required for air conditioning. In the New York case, use of the economically optimum amount of insulation results in a reduction of the electricity consumed for air conditioning of 26 percent for the gas home or 18 percent for the electric home, compared to the 1970 MPS-compliance homes.

The popularity of room air conditioners is evidenced by an exponential sales growth with a doubling time of 5 years over the past decade; almost 6 million were sold in 1970. The strong growth in sales is expected to continue since industry statistics show a market saturation of only about 40 percent.

There are about 1400 models of room air conditioners available on the market today, sold under 52 different brand names (*10*). A characteristic of the machines that varies widely but is not normally advertised is the efficiency with which energy is converted to cooling. Efficiency ranges from 4.7 to 12.2 Btu per watt-hour. Thus the least efficient machine consumes 2.6 times as much electricity per unit of cooling as the most efficient one. Figure 1 shows the efficiencies of all units having ratings up to 24,000 Btu per hour, as listed in (*10*).

From an economic point of view, the purchaser should select the particular model of air conditioner that provides the needed cooling capacity and the lowest total cost (capital, maintenance, operation) over the unit's lifetime. Because of the large number of models available and the general ignorance of the fact that such a range of efficiencies exists, the most economical choice is not likely to be made. An industry-sponsored certification program requires that the cooling rating and wattage input be listed on the nameplate of each unit, providing the basic information required for determining efficiency. However, the nameplate is often hard to locate and does not state the efficiency explicitly.

The magnitude of possible savings that would result from buying a more efficient unit is illustrated by the following case. Of the 90 models with a capacity of 10,000 Btu per hour, the lowest efficiency model draws 2100 watts and the highest efficiency model draws 880 watts. In Washington, D.C., the average room air conditioner operates about 800 hours per year. The low-efficiency unit would use 976 kilowatt-hours more electricity each year than the high-efficiency unit. At 1.8 cents per kilowatt-hour, the operating cost would increase by $17.57 per year. The air conditioner could be expected to have a life of 10 years. If the purchaser operates on a credit card economy, with an 18 percent interest rate, he would be economically justified in paying up to $79 more for the high-efficiency unit. If his interest rate were 6 percent, an additional purchase price of $130 would be justified.

In the above example, the two units were assumed to operate the same number of hours per year. However, many of the low-priced, low-efficiency units are not equipped with thermostats. As a result, they may operate almost continuously, with a lower-than-desired room temperature. This compounds the inefficiency and, in addition, shortens the lifetime of the units.

In addition to the probable economic advantage to the consumer, an improvement in the average efficiency of room air conditioners would result in appreciable reductions in the nation's energy consumption and required generating capacity. If the size distribution of all existing room units is that for the 1970 sales, the average efficiency (*10*) is 6 Btu per watt-hour, and the average annual operating time is 886 hours per year, then the nation's room air conditioners consumed 39.4 billion kilowatt-hours during 1970. On the same basis, the connected load was 44,500 megawatts, and the annual equivalent coal consumption was 18.9 million tons. If the assumed efficiency is changed to 10 Btu per watt-hour, the annual power consumption would have been 23.6 billion kilowatt-hours, a reduction of 15.8 billion kilowatt-hours. The connected load would have decreased to 26,700 megawatts, a reduction of 17,800 megawatts. The annual coal consumption for room air conditioners would have been 11.3 million tons, a reduction of 7.6 million tons, or at a typical strip mine yield of 5000 tons per acre, a reduction in stripped area of 1500 acres in 1970.

Other Potential Energy Savings

Energy-efficiency improvements can be effected for other end-uses of energy besides the three considered here. Improved appliance design could increase the energy efficiency of hot-water heaters, stoves, and refrigerators. The use of solar energy for residential space and water heating is technologically feasible and might some day be economically feasible. Alternatively, waste heat from air conditioners could be used for water heating. Improved design or elimination of gas pilot lights and elimination of gas yard lights would also provide energy savings (*11*). Increased energy efficiency within homes would tend to reduce summer air-conditioning loads.

In the commercial sector, energy savings in space heating and cooling such as those described earlier are possible. In addition, the use of total energy systems (on-site generation of electricity and the use of waste heat for space and water heating and absorption air conditioning) would increase the overall energy efficiency of commercial operations.

Commercial lighting accounts for about 10 percent of total electricity consumption (*12*). Some architects claim that currently recommended lighting levels can be reduced without danger to eyesight or worker performance (*13*). Such reduction would save energy directly and by reducing air-conditioning loads. Alternatively, waste heat from lighting can be circulated in winter for space heating and shunted outdoors in summer to reduce air-conditioning loads.

Changes in building design practices might effect energy savings (*13*). Such changes could include use of less glass and of windows that open for circulation of outside air.

Waste heat and low temperature steam from electric power plants may be useful for certain industries and for space heating in urban districts (*14*). This thermal energy (about 8 percent of energy consumption in 1970) (*15*) could be used for industrial process steam, space heating, water heating, and air conditioning in a carefully planned urban complex.

The manufacture of a few basic materials accounts for a large fraction of industrial energy consumption. Increased recycle of energy-intensive materials such as aluminum, steel, and paper would save energy. Savings could also come from lower production of certain materials. For example, the production of packaging materials (paper, metal, glass, plastic, wood) requires about 4 percent of the total energy budget. In general, it may be possible to design products and choose materials to decrease the use of packaging and to reduce energy costs per unit of production.

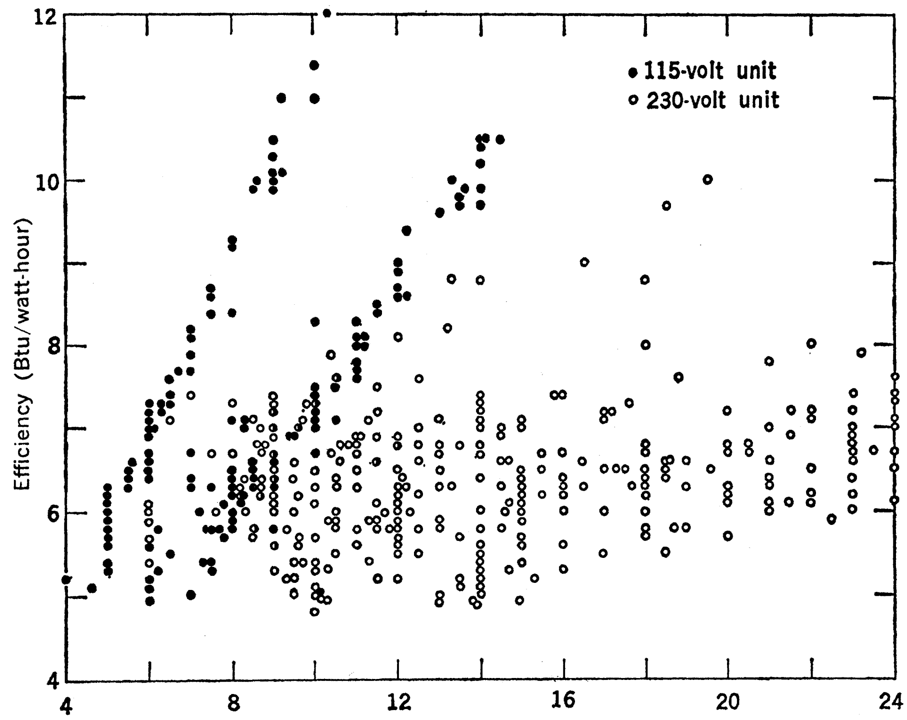

Fig. 1. Efficiency of room air conditioners as a function of unit size.

Implementation

Changes in *energy prices*, both levels and rate structures, would influence decisions concerning capital versus life costs, and this would affect the use of energy-conserving technologies. *Public education* to increase awareness of energy problems might heighten consumer sensitivity toward personal energy consumption. Various local, state, and federal *government policies* exist that, directly and indirectly, influence the efficiency of energy use. These three routes are not independent; in particular, government policies could affect prices or public education (or both) on energy use.

One major factor that promotes energy consumption is the low price of energy. A typical family in the United States spends about 5 percent of its annual budget on electricity, gas, and gasoline. The cost of fuels and electricity to manufacturers is about 1.5 percent of the value of their total shipments. Because the price of energy is low relative to other costs, efficient use of energy has not been of great importance in the economy. Not only are fuel prices low, but historically they have declined relative to other prices.

The downward trend in the relative price of energy has begun to reverse because of the growing scarcity of fuels, increasing costs of both money and energy-conversion facilities (power plants, petroleum refineries), and the need to internalize social costs of energy production and use. The impact of rising energy prices on demand is difficult to assess. According to one source (*16*):

> . . . In the absence of any information, we assume a long-run price elasticity of demand of — 0.5 (meaning that in the long-run a doubling of energy prices will reduce demand by a factor of the square root of 2, namely to about 70 percent of what it would have been otherwise).

The factors cited above (fuel scarcity, rising costs, environmental constraints) are likely to influence energy price structures as well as levels. If these factors tend to increase energy prices uniformly (per Btu delivered), then energy price structures will become flatter; that is, the percentage difference in price between the first and last unit purchased by a customer will be less than that under existing rate structures. The impact of such rate structure changes on the demand for energy is unknown, and research is needed.

Increases in the price of energy should decrease the quantity demanded and this is likely to encourage more efficient use of energy. For example, if the price of gasoline rises, there will probably be a shift to the use of smaller cars and perhaps to the use of public transportation systems.

Public education programs may slow energy demand. As Americans understand better the environmental problems associated with energy production and use, they may voluntarily decrease their personal energy-consumption growth rates. Experiences in New York City and in Sweden with energy-conservation advertising programs showed that the public is willing and able to conserve energy, at least during short-term emergencies.

Consumers can be educated about the energy consumption of various appliances. The energy-efficiency data for air conditioners presented here are probably not familiar to most prospective buyers of air conditioners. If consumers understood energy and dollar costs of low-efficiency units, perhaps they would opt for more expensive, high-efficiency units to save money over the lifetime of the unit and also to reduce environmental impacts. Recently, at least two air-conditioner manufacturers began marketing campaigns that stress energy efficiency. Some electric utilities have also begun to urge their customers to use electricity conservatively and efficiently.

Public education can be achieved through government publications or government regulation, for example, by requiring labels on appliances which state the energy efficiency and provide estimates of operating costs. Advertisements for energy-consuming equipment might be required to state the energy efficiency.

Federal policies, reflected in research expenditures, construction of facilities, taxes and subsidies, influence energy consumption. For example, the federal government spends several billion dollars annually on highway, airway, and airport construction, but nothing is spent for railway and railroad construction. Until recently, federal transportation research and development funds were allocated almost exclusively to air and highway travel. Passage of the

Urban Mass Transportation Act, establishment of the National Railroad Passenger Corporation (AMTRAK), plus increases in research funds for rail and mass transport may increase the use of these energy-efficient travel modes.

Similarly, through agencies such as the Tennessee Valley Authority, the federal government subsidizes the cost of electricity. The reduced price for public power customers increases electricity consumption over what it would otherwise be.

Governments also influence energy consumption directly and indirectly through allowances for depletion of resources, purchase specifications (to require recycled paper, for example), management of public energy holdings, regulation of gas and electric utility rate levels and structures, restrictions on energy promotion, and establishment of minimum energy performance standards for appliances and housing.

The federal government spends about $0.5 billion a year on research and development for civilian energy, of which the vast majority is devoted to energy supply technologies (*16*):

> . . . Until recently only severely limited funds were available for developing a detailed understanding of the ways in which the nation uses energy. . . . The recently instituted Research Applied to National Needs (RANN) Directorate of the National Science Foundation . . . has been supporting research directed toward developing a detailed understanding of the way in which the country utilizes energy. . . . This program also seeks to examine the options for meeting the needs of society at reduced energy and environmental costs.

Perhaps new research on energy use will reveal additional ways to reduce energy growth rates.

Summary

We described three uses of energy for which greater efficiency is feasible: transportation, space heating, and air conditioning. Shifts to less energy-intensive transportation modes could substantially reduce energy consumption; the magnitude of such savings would, of course, depend on the extent of such shifts and possible load factor changes. The hypothetical transportation scenario described here results in a 22 percent savings in energy for transportation in 1970, a savings of 2800 trillion Btu.

To the homeowner, increasing the amount of building insulation and, in some cases, adding storm windows would reduce energy consumption and provide monetary savings. If all homes in 1970 had the "economic optimum" amount of insulation, energy consumption for residential heating would have been 42 percent less than if the homes were insulated to meet the pre-1971 FHA standards, a savings of 3100 trillion Btu.

Increased utilization of energy-efficient air conditioners and of building insulation would provide significant energy savings and help to reduce peak power demands during the summer. A 67 percent increase in energy efficiency for room air conditioners would have saved 15.8 billion kilowatt-hours in 1970.

In conclusion, it is possible—from an engineering point of view—to effect considerable energy savings in the United States. Increases in the efficiency of energy use would provide desired end results with smaller energy inputs. Such measures will not reduce the *level* of energy consumption, but they could slow energy growth *rates*.

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